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Using Soft Systems Methodology as a systemic approach to safety performance evaluation

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Abstract

The purpose of this paper is to present a case study in order to show how Soft Systems Methodology (SSM) may be used for the systemic evaluation of occupational safety and health (OSH) performance and support decision making for safety improvement programs. SSM has been implemented in a large Greek Civil Service organization, which required an overall assessment of its current OSH performance, in order to formulate a program of improvement actions. Results proved that SSM provides a framework which can be used towards this purpose. The implementation of SSM resulted in a more holistic picture of the current situation, by identifying not only a wider range of problematic factors but also multiple perspectives for the same factors. Proposals for improvement changes to the existing safety management system were made. The three SSM performance evaluation criteria – efficacy, efficiency, effectiveness, were specified for each proposed safety management activity system. Finally, it was recognized that the methodology provides valuable insights into the different stakeholders' perspectives on OSH performance and that it creates motivation through its learning participatory process.

Keywords: Safety management system; safety performance evaluation; soft system methodology; systemic approach

1. Introduction

The performance evaluation process is a key step in any management system and constitutes the basis for continuous improvement. Safety performance evaluation is an essential part of safety systems, since it basically provides information on the overall system's operation in terms of development, implementation and results. In that way, safety performance evaluation influences decision making in occupational safety and health matters.

Safety performance is, in theoretical terms, a dependent variable and all direct and indirect factors that influence safety are the independent ones. These factors relate to technical, organizational, individual and environmental conditions and characteristics, specific to a particular organization [1]. Due to the multitude and complexity of these factors, even in a common workplace, the mathematical calculation of safety performance remains almost impossible. For this reason, safety researchers and professionals have designated safety performance indicators with various purposes and across several dimensions [2,3].

In recent years, emphasis is given to the use of more than one safety performance indicators and to the combination of their results for a more complete assessment [4,5,6,7]. However, the complementary or combining use of safety performance indicators does not satisfy the need for a holistic approach in safety performance evaluation, which is increasing at the present dynamic society [1].

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This paper outlines a systemic approach to tackle problems involving the evaluation of the performance of a safety management system. This approach refers to Checkland's Soft Systems Methodology (SSM) [8,9] and more specifically to his concepts of "monitoring and controlling" a system throughout a set of three performance evaluation criteria: efficacy, efficiency and effectiveness. After a review of SSM and a discussion on its applicability for the evaluation of safety performance in the following sections, the paper describes a case study in a Greek Civil Service organization where SSM was implemented for the performance evaluation of a set of proposed safety management activities.

2. Soft Systems methodology

SSM is an established systems-based approach which was developed as a way to use system concepts in (social) organizations for making interventions and understanding their efforts. At the core of SSM lies the distinction between 'hard' and 'soft' systems thinking, with the former seeing the world as a set of inter-relating systems, which can be re-engineered in order to be improved, and the latter seeing the world as a complex and confusing entity, which can be explored through a systemic process, organized as a learning system.

SSM is concerned with unstructured or ill-structured problematic situations where there is no consensus among stakeholders, even for what the actual problem is. SSM aims at accommodating different perspectives through conceptual models of human activity systems. These models are then used to decide on interventions for the resolution, or improvement, of the situation.

Over the years, SSM has evolved into a less structured and broader methodology of structuring issues and developing interventions and is now represented by the less formal four activities model. The main stages of this model are the following:

(1) Finding out about the problem situation. This is a continuous process, based not only on the analysis of facts, but also on a cultural analysis, which examines the intervention itself, the social system (meaning the interaction of roles, norms and values in the organization of the problem situation) and the political system (meaning the power structure and related activities which aim at reaching an accommodation of different interests). This stage results in a 'rich picture', that provides a holistic view of the problem situation.

(2) Building conceptual models. This stage of SSM is about conceptualizing purposeful human activity systems which are considered relevant to the problem situation and, when compared with reality, can lead to the selection of meaningful improvement interventions. A 'root definition' expresses the core purpose of the activity system as a transformation process and is further elaborated by considering the elements of the mnemonic CATWOE (Table 1).

Table 1. CATWOE elements

C	Customers, who are the victims or beneficiaries of transformation.
A	Actors, who would do transformation.
T	Transformation from input to output.
W	Worldview, viewpoints and assumptions that make the transformation meaningful.
O	Owner, to whom the 'system' is answerable and/or who could stop transformation.
E	Environmental constraints, which influence but do not control the system.

In order to model each system, it is also required to add the activities of monitoring and control, since these models are presented in a form consistent with system ideas, including that of adaptation in changing circumstances. To support these activities, evaluation criteria are introduced. The criteria used in SSM answer to general questions, which judge the success of any transformation process. The core criteria, named the 3 E's, are: Efficacy (does the means work?), Efficiency (amount of output divided by amount of resources used), Effectiveness (is transformation meeting the longer term aim?) and, in later versions, were complemented by two additional criteria: Ethicality and Elegance.

(3) Comparing models with reality and proposing for change. The conceptual models developed in the previous stage, serve as a means to a debate regarding the changes that would improve or resolve the problem situation. If these models are perceived as being truly relevant to the problem situation, then the changes that may derive from their comparison to the perceived reality can be seen as systemically desirable. If these changes are further regarded as meaningful within a given culture, then they are also considered as culturally feasible. In formulating proposals for

changes, an accommodation between conflicting interests must be achieved to enable action.

(4) Taking action in the situation to bring improvement. The last stage of SSM refers to the implementation of the proposed changes which is expected to modify also the existing culture. Since implementation itself can be considered as a problem situation, in many cases SSM is used to tackle it.

3. Relevance of SSM to safety performance evaluation

The issue of evaluating the performance of a system is related to the more general problem of system improvement. In management sciences, both qualitative and quantative approaches have been proposed for the assessment of a system's performance, and in many instances a combination of these approaches has been implemented [10].

SSM represents a qualitative approach, subjective in nature, in which stakeholders consider levels of achievement in qualitative terms. Even when the criteria of efficacy, efficiency and effectiveness are assessed through the measurement of quantified indicators, both the selection of these indicators and their correspondence to qualitative levels of achievement of the three criteria, are the subjective outcomes of a participatory process trying to accommodate different views and perspectives of all stakeholders.

In order to support the implementation of SSM in the evaluation of safety performance, some considerations regarding the purposes and context of safety performance evaluation are required. Safety performance evaluation has the following three main purposes [11,12]: (i) to provide information on the progress and current status of the strategies, processes and activities used by an organization to control risks to health and safety, (ii) to support decisions regarding improvements of the safety management system, and (iii) to motivate those in position to take the above decisions.

One of the challenges, that decision makers face, is the broad context under which safety performance evaluation takes place. It is more convenient, and usually occurs, to perform an evaluation in a specific problematic area, which requires immediate management involvement. However, according to systems theory, technical, organizational, human and external factors related to safety performance are all inter-acting; a problem in one area may have its origin in another area of the system. A single evaluation of a group of factors will leave out crucial information for decision making [1].

Moreover, it should be acknowledged that measurement of safety performance indicators produces data that must be evaluated in order to gain knowledge. Evaluation involves some method of judgment about the measurement data, based on criteria. Judgment requires a viewpoint, since different viewpoints or perspectives may lead to different results [13]. Therefore, the implementation of multiple evaluation criteria and perspectives is critical for a holistic, or better systemic, approach to safety performance evaluation.

Accommodation of different perspectives is inherent in SSM, which offers a rigorous systemic way of satisfying all three purposes of safety performance evaluation. Starting from the conceptual models which are developed in SSM, these include an operational system tackling a problem situation (safety management in our case) and a monitoring and control system which inspects the performance of the operational system and helps it to adapt to changes. Therefore, once an accommodation of different views on which activities, proactive and reactive, should constitute an organization's safety management system, the three basic evaluation criteria – efficacy, efficiency and effectiveness - proposed by SSM can be applied in each activity. At the stage of proposing for change, these criteria can be further elaborated, by defining levels of achievement and selecting the safety performance indicators which will be used for their measurement or assessment.

Regarding the information on the current status of safety performance, the analysis of all relevant information (including safety measurement data and safety management systems' goals and results) together with the in-depth cultural analysis required by SSM and a consideration of history and of external constraints, can provide a much richer picture of the situation, than the one usually deriving from incident statistics or risk assessments.

Supporting decisions for improvement is inherent in SSM, since actions for improvement, defined in SSM as 'systemically desirable and culturally feasible changes', are decided by comparing the conceptual models of human activity relevant systems, with the real world situation. The decision is based on the accommodation of the different perspectives on what is relevant and what is meaningful. Finally, SSM is based on enacting a systemic process of learning and for this reason, motivation for action is the result of this participatory approach.

4. Case study

SSM was applied in a Greek Civil Service organization which is concerned with policy formulation, organization, operation and control of one of the country's major transport sectors. This study followed a previous one, which had as an aim to implement SSM for the overall assessment and further improvement of the organization's current occupational health and safety performance evaluation process.

The researchers that led the intervention collaborated with a working group of six representatives from middle management, employees and union members of the organization, who offered their diverse insights and perspectives on the

issue under study. The following paragraphs describe the SSM process implemented, which was based on the four activities model described above, and the outcomes of the study.

4.1. Finding out about the problem situation

This initial stage necessitated the development of a 'rich picture' of the existing situation, based on all information that was considered relevant to the problem situation (safety management), including cultural and political analysis of the situation. Safety data for the past ten years were collected, including incident data, risk assessment reports, safety recommendations for corrective and preventive actions and safety procedures. Information with regard to existing occupational health and safety management practices, and views on the various social norms, roles, values and power relationships was also recorded based on the accounts of members of all organization hierarchy levels, union members and employees of the external consultant offering occupational health and safety services.

During this stage, it became apparent that there was no formal safety management system, however a number of activities related with the control of occupational health and safety risks were taking place by different organizational units. These activities were mainly addressing minimum legal requirements, while improvement of working conditions and developing a positive safety culture were receiving less attention. Monitoring and evaluation of the outcome of these activities was seldom.

4.2. Building conceptual models

Four human activity systems were identified as relevant to the ideal safety management system, as this was perceived by the working group. The transformation processes related to these systems refer to: (a) identification of and compliance with occupational safety and health (OSH) legislation, (b) risk assessment and control, (c) incident reporting and investigating and (d) development of a positive safety culture. The conceptual models of these systems are depicted in Appendix A (Figures 1-4), together with their root definitions and CATWOE elements.

4.3. Comparing models with reality and proposing for change

The models resulting from the previous stage were used as a means for a debate on the improvements considered desirable and feasible, in order to move towards the ideal situation expressed in the models. Different views were accommodated and a list of several changes was finally drafted by the workgroup, in order to discuss their desirability and feasibility with top management who would take the final decisions.

Among the various improvements discussed, evaluation criteria and safety performance indicators were selected by the working group. The three general criteria of efficacy, efficiency and effectiveness, were specifically defined for each relevant system, together with their respective levels of achievement. One or more safety performance indicators were selected for each criterion, thus resulting in an Evaluation Table. In Table 2, the evaluation table for the relevant system of identification of and compliance with OSH legislation is provided indicatively.

Table 2. Performance evaluation for the transformation process of identifying and complying with OSH legislation

	Efficacy	Efficiency	Effectiveness
Definition	This process ensures an accurate and up-to-date record of legal obligations and prompt remedial action	This process is performed with minimal resources	This process promotes overall occupational health and safety
Levels of achievement	Efficacious / Not Efficacious	Under budget / Within budget / Over budget	Minor / Moderate / Major
Safety performance indicators	Review of OSH Improvement Program when a new legal requirement occurs within a week	Annual cost of remedial actions	Percentage of remedial actions related to legal requirements to the total number of actions recorded in the OSH Improvement Program per year
	No pending remedial actions in OSH Improvement Program related to legal requirements	Annual cost of OSH Experts and/or Safety Unit	Subjective assessment of effectiveness by representatives of all stakeholders
	Competence of OSH Experts & Safety Unit		

4.4. Taking action in the situation to bring improvement

All information collected through the three stages was included in the final report prepared by the researchers. A wide range of issues relevant to the wider issue of safety management were included in the report. Proposals for changes which would lead to the ideal safety management practices and their evaluation, as these were identified and debated over by the workgroup, were also included.

5. Conclusions

This paper addresses the issue of evaluating safety performance by taking into consideration multiple perspectives and goals, as these are expressed by all stakeholders in a specific organizational setting. It is argued that in that way safety performance will be evaluated in a way consistent to the needs and culture of any given organization, thus it would better fulfil its objectives. The proposed participatory approach for this development is the implementation of the well-established Soft System Methodology (SSM).

The application of SSM and its outcomes proved that it can be used as a tool to address the evaluation of safety management activities in complex organizational settings. Participants and management acknowledged that the methodology provided valuable insights into the different stakeholders' perspectives regarding the way occupational health and safety should be managed and evaluated throughout the organization. Moreover, through the participatory approach of SSM, those involved, learned about and understood better the problem situation, hence they were more motivated to support the proposed improvement interventions.

References

[1] Sgourou, E., Katsakiori, P., Goutsos, S., Manatakis, Em., 2010. Assessment of selected safety performance evaluation methods in regards to their conceptual, methodological and practical characteristics, Safety Science 48, p. 1019.
[2] Hopkins, A., 2009. Thinking about process safety indicators, Safety Science 47, p. 460.
[3] Harms-Ringdahl, L., 2009. Dimensions in safety indicators, Safety Science 47, p. 481.
[4] Newell, S., 2001. A new paradigm for safety and health metrics: Framework, tools, applications and opportunities, Organization Resources Counselors Inc. Retrieved from: http://www.achmmchicago.org/Conference/Protected/OSHA%20Industrial%20Hygiene%20Safety%20Track/Newell_Stephen_A.PDF
[5] Petersen, D., 2001. The Safety Scorecard: Using Multiple Measures to Judge Safety System Effectiveness, Occupational Hazards. Retrieved from: http://ehstoday.com/safety/best-practices/ehs_imp_34484/
[6] Sherif, M., 2003. Scorecard Approach to Benchmarking Organizational Safety Culture in Construction, Journal of Construction Engineering and Management 129, p. 80.
[7] Mengolini, A., Debarberis, L., 2008. Effectiveness Evaluation Methodology for Safety Processes to Enhance Organizational Culture in Hazardous Installations, Journal of Hazardous Materials 155, p. 243.
[8] Checkland, P., 1981. Systems Thinking, Systems Practice, John Wiley & Sons. Ltd, Chichester, U. K.
[9] Checkland, P., Scholes, J., 1999. Soft Systems Methodology in Action. John Wiley & Sons. Ltd, Chichester, U. K.
[10] Paucar-Caceres, A., 2009. Measuring the Performance of a Research Strategic Plan System Using the Soft System Methodology's Three 'Es' and the Viable System Model's Indices of Achievement, System Practice and Action Research 22, p. 445.
[11] Health and Safety Executives, 2001. A Guide to Measuring Health & Safety Performance. Retrieved from: http://www.hse.gov.uk/opsunit/perfmeas.pdf
[12] Hale, A., 2009. Why safety performance indicators?, Safety Science 47, p. 479.
[13] Williams, R., 2010. Systems Thinking and Capacity Development in the International Arena, in "Beyond LogFrame: Using Systems Concepts in Evaluation" Nobuko Fujita, Editor. Foundation for Advanced Studies on International Development, Tokyo.

Appendix A. Conceptual models of relevant activity systems

A.1. Identification of and compliance with OSH legislation

Root definition: A system to ensure that occupational health and safety (OSH) legal requirements are continuously identified by the Organization's OSH Experts and are met by the Top Management in a prompt and organized manner.

CATWOE elements:
Customer: Top Management
Actors: OSH Experts, Safety Unit
Transformation: OSH Legislation not always identified and met >> OSH Legislation identified and met
Worldview: OSH legislation describes the minimum requirements that must be met at all times in order to protect employees' health and safety.
Owner: Top Management
Environmental constraints: Lack of resources (specialized personnel, safety budget)

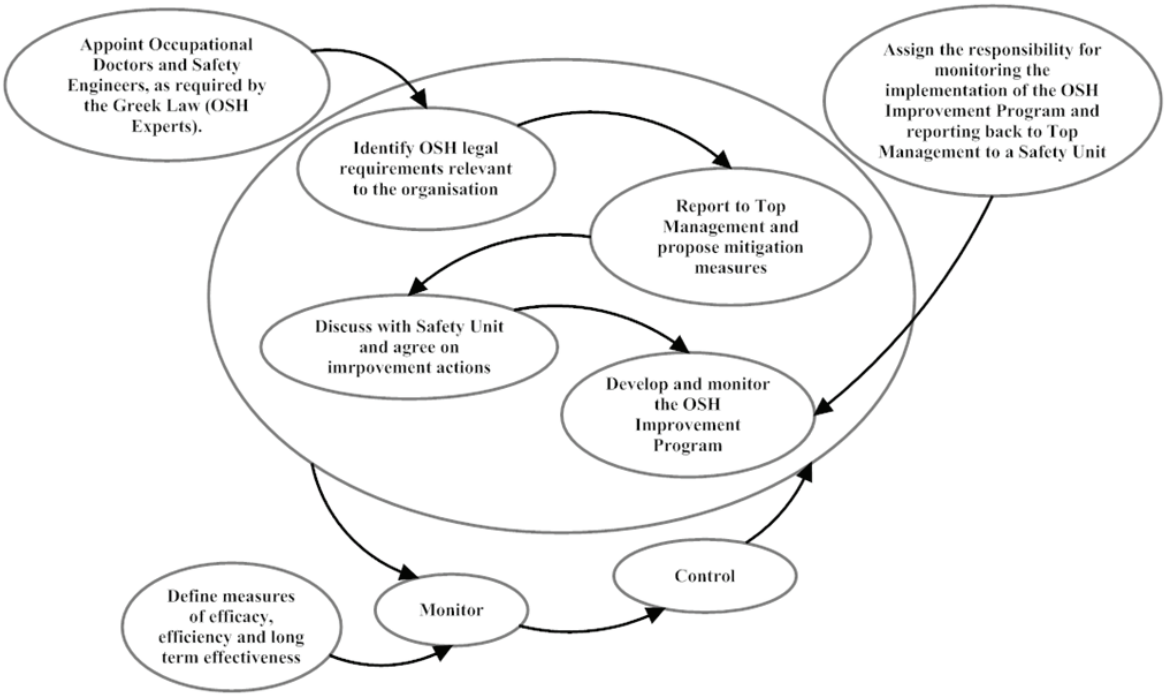

Fig. 1. Identification of and compliance with OSH legislation relevant system.

A.2. Identification and control of risks

Root definition: A system to ensure that hazards to occupational health and safety (OSH) are identified, relevant risks are assessed and risk control actions are planned and implemented by the Top Management.

CATWOE elements:
Customer: Top Management
Actors: OSH Experts, Safety Unit
Transformation: OSH Risks not always assessed and controlled >> OSH Risks assessed and controlled
Worldview: OSH Risks to employees' health and safety should be assessed, through a participatory approach, and adequately controlled.
Owner: Top Management
Environmental constraints: Lack of risk knowledge, Lack of resources (specialized personnel, safety budget)

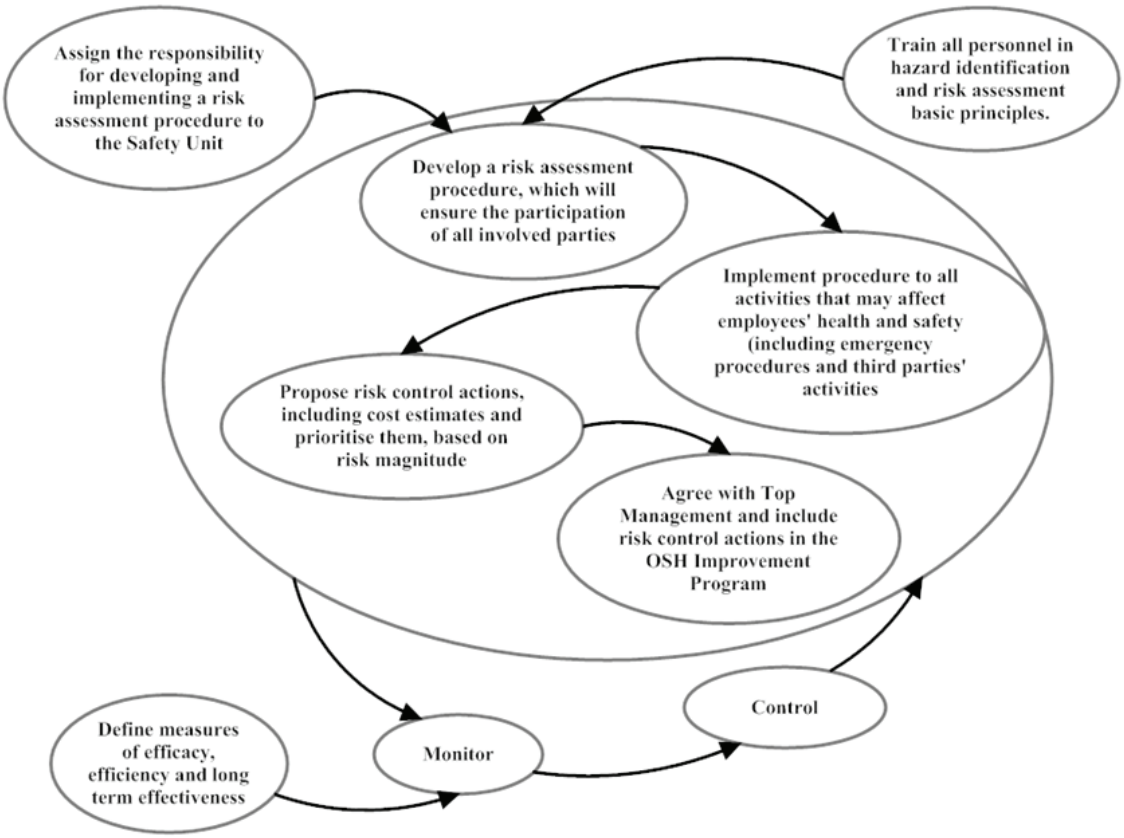

Fig. 2. Identification and control of risks relevant system.

A.3. Reporting and investigating of incidents

Root definition: A system to ensure that incidents related to occupational health and safety (OSH) are reported by all employees, investigated by the responsible units and remedial action is planned and implemented by the Top Management.

CATWOE elements:
Customer: Top Management
Actors: OSH Experts, Safety Unit
Transformation: Incidents not always reported and investigated, and remedial action not always taken >> Incidents reported and investigated, and remedial action taken
Worldview: Investigation of incidents enables organizational learning and leads to the improvement of safety, through the implementation of remedial actions.
Owner: Top Management
Environmental constraints: Blaming culture, Lack of resources (specialized personnel, safety budget)

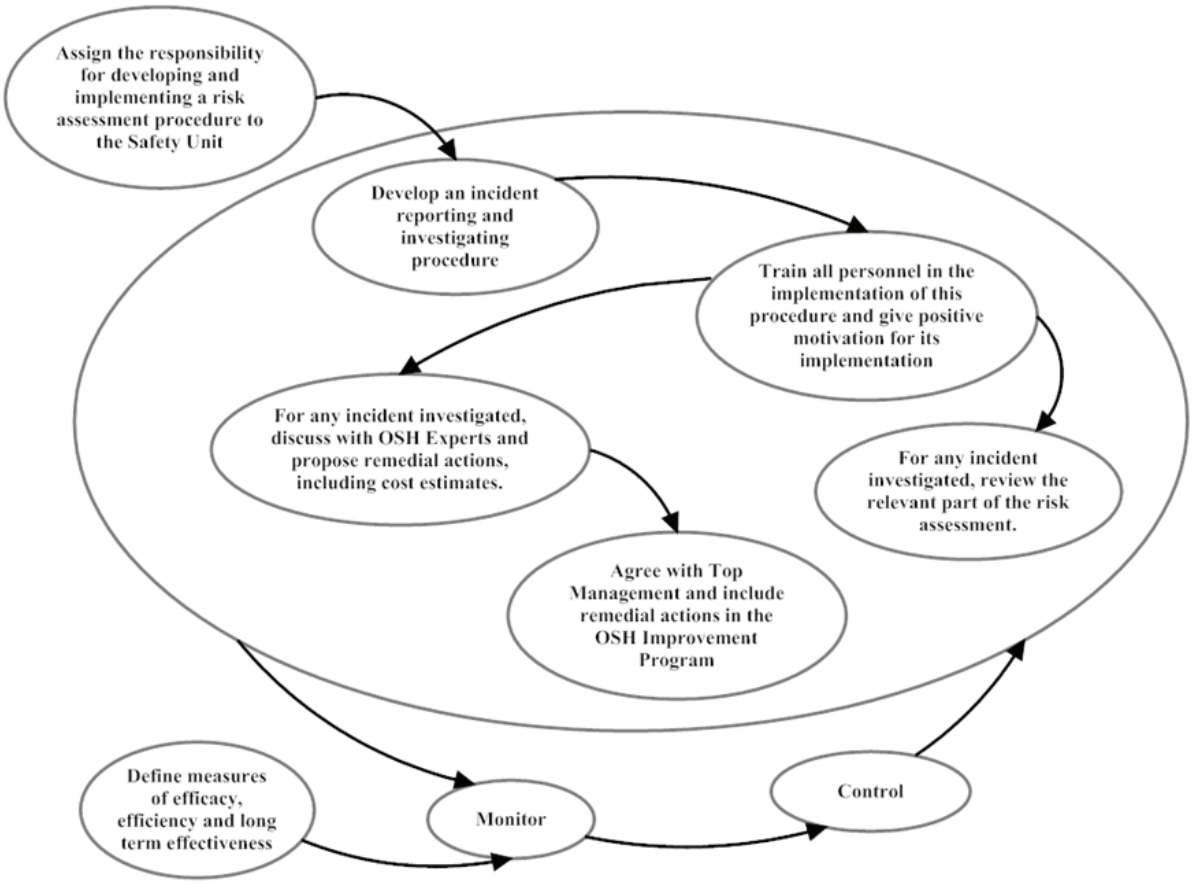

Fig. 3. Reporting and investigating of incidents relevant system.

A.4. Development of a positive safety culture

Root definition: A system to ensure that a positive safety culture is developed and supported by the Top Management throughout the organization.

CATWOE elements:
Customer: Top Management
Actors: Top Management
Transformation: Negative Safety Culture >> Positive Safety Culture
Worldview: A positive safety culture starts from the demonstration of top management's commitment to safety and results in safe behaviors and motivation for action for all employees
Owner: Top Management
Environmental constraints: Blaming culture in civil service, External influences to strategic decisions including occupational health and safety policy and programs

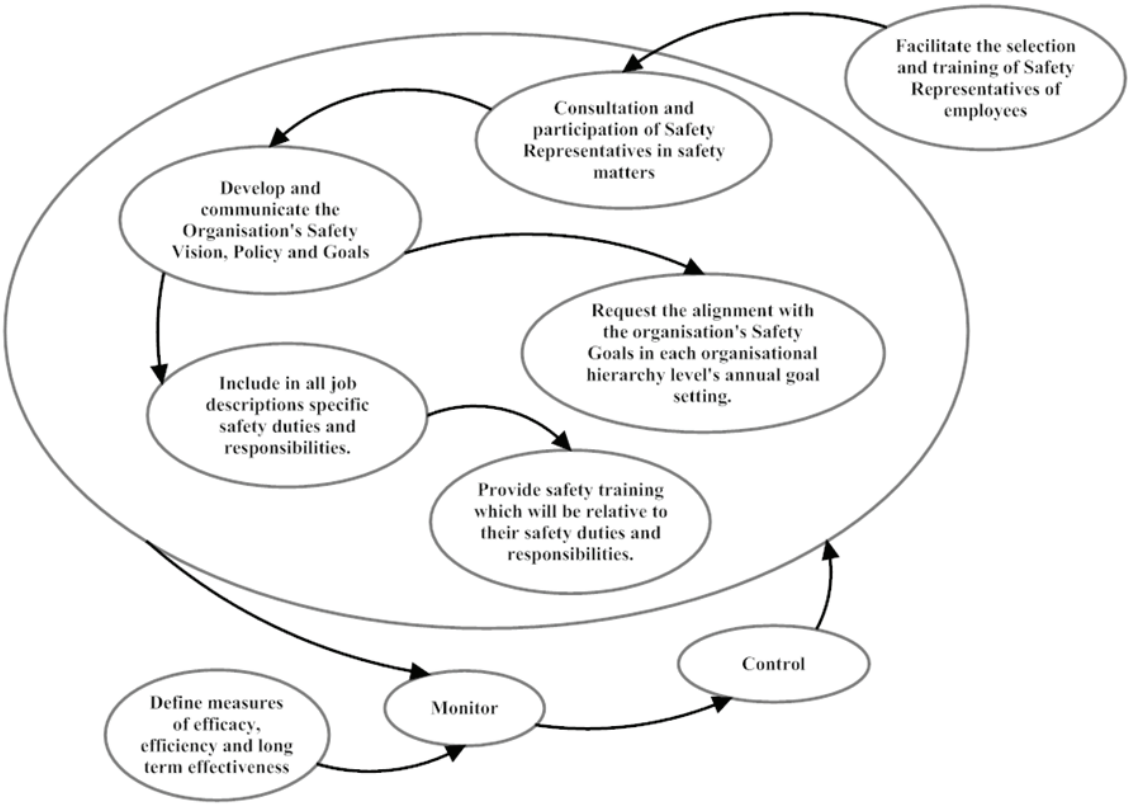

Fig. 4. Development of a positive safety culture relevant system.